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Abstract

From an extensive review of the literature of total quality management (TQM), eleven constructs of TQM implementation were identified. An instrument measuring these constructs was developed. The reliability and validity of the instrument were tested and validated using data from 212 Chinese manufacturing companies. Various methods were employed for this test and validation. Comparisons between this instrument and the three other quality management instruments were made. It was concluded finally that the instrument presented in this paper was reliable and valid. Researchers will be able to use this instrument for developing quality management theory. Industrial practitioners will be able to use this instrument to evaluate their TQM implementation so as to target improvement areas.

Keywords: Total quality management, Implementation, Measurement, Empirical research, Chinese manufacturing companies

1. Introduction

The level of awareness of total quality management (TQM) has increased considerably over the past few years. There have been many discussions on the subject of TQM. However, the contents of these papers differ to a considerable degree. Some focus on the conceptual issues of TQM (e.g., Reeves and Bednar, 1994; Anderson and Schroeder, 1994; Dean and Bowen, 1994; Waldman, 1994), while others focus on the practical and empirical issues of TQM (e.g., Forza and Filippin, 1998; Choi and Eboch, 1998; Anderson et al., 1995; Mann, 1992; Mann and Kehoe, 1994; Blauw, 1990). There is a widespread consensus that TQM is a way of managing an organisation to improve its overall effectiveness and performance. There is a less agreement as to what the primary constructs of TQM are, or what the overall concept of TQM is. No uniform view of TQM exists today. So far, TQM has come to mean different things to different people (Hackman and Wageman, 1995).

Although many Chinese manufacturing companies began to implement TQM from 1978 onwards, China still lacks effective TQM systems and application at the enterprise level, however. Some basic quality principles and modern quality management methods have not been widely used by Chinese manufacturing enterprises (Zhao et al., 1995). Although great efforts have been made by the Chinese government to stimulate companies to implement TQM and improve product quality, there has not been satisfactory progress. The country’s product quality as a whole is still at a relatively low level (Zhang, 1998a). A number of quality management problems still remain unsolved. After reviewing the literature related to China’s quality management, it became very clear that little empirical research has been conducted in the area of TQM implementation in Chinese manufacturing companies. The current situation of TQM implementation in Chinese manufacturing companies still remains unclear, therefore. Due to lack of empirical studies in the field of TQM, it is difficult for Chinese manufacturing companies to obtain sufficient information to support their TQM implementation practices. As a consequence, many Chinese manufacturing companies have experienced difficulties or failures in implementing TQM.

In order to bridge the gap and provide Chinese manufacturing companies with practical assistance in the area of TQM implementation, this research aimed at identifying TQM implementation constructs, developing an instrument for measuring these constructs, and empirically validating the instrument using data from Chinese manufacturing companies. Researchers will be thus able to use this instrument for developing quality management theory related to Chinese manufacturing companies. Chinese industrial practitioners will be able to use this instrument to evaluate the status of their TQM implementation so as to target improvement areas.

Several similar studies dealing with empirically validated scales for integrated quality management have already been conducted (e.g., Saraph et al., 1989; Flynn et al., 1994; Ashire et al., 1996). The three instruments are different in terms of constructs and measurement items. Each one has its own strengths and weaknesses. According to the goal of this study and the author's understanding of TQM, none of these instruments could have been directly employed in this study. A new instrument for measuring TQM implementation for Chinese manufacturing companies had to be therefore developed. However, the instrument presented in this paper represented a significant departure from their instruments in ways that are presented here.

The rest of this paper is organised as follows. Section two presents the eleven TQM implementation constructs. Section three involves instrument development and information concerning respondent companies. The procedures and the methods used for testing and validating the TQM implementation instrument are provided in section four. Finally, section five concludes this paper together with some discussions.

2. Developing TQM Implementation Constructs

Over the past few decades, writers such as Deming (1986), Crosby (1979), Juran and Gryna (1993), Feigenbaum (1991), Ishikawa (1985), and others have developed certain propositions in the area of quality management. Their insights into quality management provide a good understanding of quality management principles. World-wide, there are several Quality Awards, such as the Deming Prize (1992) in Japan, the European Quality Award in Europe (1994) and the Malcolm Baldrige National Quality Award (1997) in the United States of America. Each award is based on a perceived model of TQM. They do not focus solely on product, service perfection or traditional quality management methods, but consider a wide range of management activities, behaviour and processes which influence the quality of the final offerings. These award models provide a useful audit or assessment framework against which organisations can evaluate their quality management methods, the deployment of these methods, and the end business results.

Based on the comprehensive review of the TQM literature, the following eleven constructs were considered to be the TQM implementation constructs (1) Leadership, (2) Supplier Quality Management, (3) Vision and Plan Statement, (4) Evaluation, (5) Process Control and Improvement, (6) Product Design, (7) Quality System Improvement, (8) Employee Participation, (9) Recognition and Reward, (10) Education and Training, and (11) Customer Focus. Detailed explanations of the eleven theoretical constructs will be presented in the following paragraphs.

2.1 Leadership

The European Quality Award and the Malcolm Baldrige Quality Award recognise the crucial role of top management leadership in creating the goals, values and systems that guide the pursuit of continuous performance improvement. Recognition of the critical role of top management and its responsibility in pursuit of quality improvement echoes the arguments put forward by gurus of quality such as Deming, Juran, and Crosby. A predominant theme in TQM literature is that strong commitment from top management is vital. The foundation of an effective TQM effort is commitment. Lack of top management commitment is one of the reasons for the failure of TQM efforts (Brown et al., 1994). Garvin (1986) reports that high levels of quality performance have always been accompanied by an organisational commitment to that goal; high product quality do not exist without strong top management commitment. Many such empirical studies have also found that top management support for quality is a key factor in quality improvement. If top managers are committed to quality, they should not only actively be involved in quality management and improvement process, but also strongly encourage employee involvement in quality management and improvement process. In addition, they should learn quality-related concepts and skills, and arrange adequate resources for employee education and training. Various quality-related issues should also be often discussed in top management meetings. Top management should pursue long-term business success and focus on product quality rather than yields.

2.2 Supplier Quality Management

Supplier quality management is an important aspect of TQM since materials and purchased parts are often a major source of quality problems. The Malcolm Baldrige Quality Award (1997) also recognises the importance of supplier quality. Garvin (1983) finds that organisations that manufacture the highest quality products have purchasing departments that rank quality rather cost minimisation as their major objective. Conversely, in organisations with the lowest quality performance, he finds that the primary objective of the purchasing department was to obtain the lowest price for technically acceptable components. Poor quality of supplier products results in extra costs for the purchaser; e.g., for one appliance manufacturer, 75 percent of all warranty claims were traced to purchased components for the appliances (Juran and Gryna, 1993). If organisations pursue good supplier quality management, they should establish long-term co-operative relations with their suppliers, often participate in supplier quality activities, have detailed information concerning supplier performance, give feedback on the performance of suppliers' products, regularly conduct supplier quality audits, and regard product quality as the most important factor for selecting suppliers.

2.3 Vision and Plan Statement

A vision statement describes how a company wants to be seen in its chosen business. As such, it describes standards, values, and beliefs. A vision is above all an advertisement of the intention to change. It propels the company forward and acts against complacency. A vision statement usually cascades down to mission statements that detail short-term site (plant) aims or departmental aims. In order to realise a vision statement, an organisation must make plan statements which support the realisation of the vision. These plans may be a detailed business plan, a quality policy, a quality goal, and a quality improvement plan. These plans and statements should be well communicated to the employees of organisations and in return employees will be encouraged in their commitment to quality. In order to make these plans and statements, employees from different levels should be involved.

2.4 Evaluation

Evaluating the situation in an organisation's quality management practices provides an important base for organisations to improve their quality management practices. Juran and Gryna (1993) state that a formal evaluation of quality provides a starting point by providing an understanding of the size of the quality issue and the areas demanding attention. Benchmarking is a powerful tool to use as a continuous process of evaluating an organisation's products, services, and processes against those of its toughest competitors or those of organisations renowned as world-class or industry leaders. Evaluation activities consist of evaluation for various policies and strategies, quality audit, quality costs analysis, department/function performance evaluation, and employee performance evaluation. In order to conduct evaluation activities, companies should have various pieces of quality-related information, such as defect rates, scraps, etc. This information should be communicated to employees in order to stimulate employees to make things better. Moreover, the aim of evaluation is improvement rather criticism.

2.5 Process Control and Improvement

A key part of any total quality strategy is the management of processes (Porter and Parker, 1993). Process refers to some unique combinations of machines, tools, methods, materials, and people engaged in production (Juran and Gryna, 1993). Process management focuses on managing the manufacturing process so that it operates as expected, without breakdowns, missing materials, fixtures, tools, etc., and despite work-force variability. One important matter in process management is the maintenance of process capability to meet production requirements. One aspect of process management is equipment maintenance, which ensures that variation is kept within acceptable bounds, keeping the manufacturing process running smoothly. Good process management should involve precisely documenting various process procedures, including giving instructions for equipment operation in order to minimise the likelihood of operator errors. Some methods, such as PDCA cycle, seven QC tools, statistical process control (SPC), sampling and inspection are effective for process control and process improvement.

2.6 Product Design

Product design is an important dimension of quality management. For complex products, errors during product development cause about 50 percent of fitness-for-use problems (Juran and Gryna, 1993). Sound product design meets or exceeds the requirements and expectations of customers better than the competitors, leading to an increased market share. For improving product design, design engineers are required to have some shop floor and marketing experiences. Customer requirements and production cost should be thoroughly considered during the process of product design. Different departments in an organisation should participate in new product development. Before production, new product design should be thoroughly reviewed in order to avoid problems happening during production. Experimental design (Zhang, 1998b) and quality function deployment (Daetz et al., 1995) are two important and effective methods in product design.

2.7 Quality System Improvement

A documented quality system as part of a TQM strategy can contribute to TQM by managing the organisation’s processes in a consistent manner. A quality system is defined as the organisational structure, procedures, processes and resources needed to implement quality management (ISO 8402, 1994). In 1987, ISO published the ISO 9000 standards series on quality management and quality assurance. When ISO 9000 is implemented, a quality manual, quality procedures, and work instructions are established. An organisation may eventually apply to be registered as having an ISO 9001 (9002 or 9003) quality certificate.

2.8 Employee Participation

By personally participating in quality improvement activities, employees acquire new knowledge, see the benefits of the quality disciplines, and obtain a sense of accomplishment by solving quality problems. The participation leads to lasting changes in behaviour. Participation is decisive in inspiring action on quality improvement (Juran and Gryna, 1993). Participation may enable the employees to improve their personal capabilities, increase their self-respect, commit themselves to the success of their organisations, and/or change certain personality traits. Participation may also change employees' negative attitudes and instil in the employees a better understanding of the importance of product quality. Participation may contribute to the establishment of a company-wide quality culture. Employees in organisations should be encouraged to report their work problems. Good employees' suggestions should be implemented after being evaluated. Methods such as cross-functional teams, within-functional teams, QC circles, voluntary teams, and suggestion activities can be used for encouraging employee participation.

2.9 Recognition and Reward

It almost goes without saying that an important feature of any quality improvement program is showing due recognition for improved performance by any individual, section, and department or division within the company (Dale and Plunkett, 1990). To effectively support their quality efforts, organisations need to implement an employee compensation system that strongly links quality and customer satisfaction with pays (Brown et al., 1994). Recognition and reward activities should effectively stimulate employee commitment to quality improvement. Otherwise, these activities are failures. Working condition improvements, salary promotions, position promotions, financial awards for excellent suggestions are good methods for recognition and reward.

2.10 Education and Training

Deming (1986) stresses the importance of education and training for continual updating and improvement. Many research results reveal that education and training is one of the most important elements in a successful implementation of

TQM (e.g., Mann, 1992). The research confirms what most organisations already have realised, namely, that education and training is an integral and essential part of the TQM initiative. Investment in education and training is vitally important for TQM success. Employees should be regarded as valuable, long-term resources worthy of receiving education and training throughout their career. All management personnel, supervisors, and employees should accept quality education and training such as quality awareness education and quality management methods education.

2.11 Customer Focus

To achieve quality, it is essential to know what customers want and to provide products or services that meet their requirements (Ishikawa, 1985). A successful organisation recognises the need to put the customer first in every decision made. The key to quality management is maintaining a close relationship with the customer in order to fully determine the customer's needs, as well as to receive feedback on the extent to which those needs are being met. The customer should be closely involved in the product design and development process, with inputs at every stage of the process so that there is less likelihood of quality problems once full production begins (Flynn et al., 1994). The ultimate measure of company performance is customer satisfaction, which may very well predict the future success or failure of an organisation (Kanji and Asher, 1993). In order to improve customer satisfaction, customer complaints should therefore be treated with top priority. Warranty on sold products should also be provided. Methods that can be used for customer focus efforts include collections of customer complaint information, market investigations, and customer satisfaction surveys.

3. Research Methodology

This section explains the development of an instrument that measures the eleven TQM implementation constructs and describes sampled companies used for conducting large-scale questionnaire surveys in China. Information about respondent companies is also provided in this section.

3.1 Instrument Development

The aim of this study is to develop an instrument for measuring TQM implementation for Chinese manufacturing companies. To reach such a goal, a set of items for measuring TQM implementation constructs had to be well developed. This was realised on the basis of a thorough review of the TQM literature, expert guidance, and input from colleagues.

I will firstly describe some of difficulties experienced in developing this instrument. In this study, the most reviewed TQM literature was in English. The instrument was thus first developed in English. However, this instrument was actually used for collecting information in China. The English version thus had to be translated into Chinese. This translation might have biased the original design of the instrument. A few quality management terms, such as benchmarking, could not be precisely translated into Chinese terms. The instrument had to be easily understood by respondents and no confusion had to have been caused. Otherwise, the research findings might have been biased.

In this study, various measures were taken in order to minimise these potential problems. The English version was translated into Chinese by a Chinese researcher who was currently doing quality management research in a western country. A few years ago, he worked in the field of quality management in China. It was assumed that he had enough knowledge of quality management in both English and Chinese. A few English terms were translated into Chinese by providing additional explanation so that respondents could understand them better. After the translation, the Chinese version of the instrument was presented to three quality managers who worked in different Chinese manufacturing companies. They were asked about (1) whether the items were stated in a shared vocabulary, (2) whether the items were precise and unambiguous, (3) whether there were biased wordings. Some alterations were made according to their suggestions. During the author’s research visit to China, the Chinese version instrument was formally pre-tested on various people (e.g., governmental officials, consultants, researchers, practitioners, and quality managers). The author interviewed these people and asked them to provide feedback on ease of comprehension, clarity of the specific items, suggestions for possible change, and suggestions for additional items, etc. Their suggestions were carefully evaluated by the researcher. Based on this, the Chinese version instrument was further modified. After this step, the researcher was confident that the instrument could be used for the large-scale survey. The final Chinese version instrument consisted of 79 items. The Appendix lists the instrument that was retranslated back into English from the final Chinese version by the same translator. If readers request a Chinese version of the instrument, the author will provide it. Following other similar studies (e.g., Flynn et al., 1994), a widely used 5-Likert scale was employed for scoring responses (1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree).

3.2 Sample

A mail survey was judged to be the most appropriate method for collecting data for empirically testing and validating the instrument. The survey was administered in Liaoning province in China between July and October 1998. The type of sample and the number of companies were determined on the basis of meeting the information requirements. In this study, all of the sampled companies were from Liaoning province, one of the most important industrial centres in China. In the Liaoning region, there were more than one thousand large- and medium-sized manufacturing companies. Almost all of these companies implemented TQM, or at least part of TQM. They therefore had some knowledge of TQM implementation. In this study, only manufacturing firms with annual sales greater than RMB 10 million (RMB is the Chinese currency, USD $ 1 = RMB 8.30) were randomly selected for investigations.

The company information was obtained from the Liaoning Provincial Statistics Bureau. In Liaoning province, there were 2,929 manufacturing firms with annual sales in excess of RMB 10 million in the year 1997. A sample of 900 manufacturing companies was randomly selected from the database. This was done with the help of a computer. The sample size was decided after considering the expected response rate, the requirements for performing statistical analysis, and the survey cost. The 900 companies were divided into four groups on the basis of industrial sector, 301 for machinery, 180 for chemicals, 97 for electronics, and 322 for other industrial sectors. The Liaoning Provincial Machinery Bureau, the Liaoning Provincial Chemicals Bureau, the Liaoning Provincial Electronics Bureau, and the Liaoning Provincial Quality Management Association sent 301, 180, 97, and

322 questionnaires respectively to quality managers in these companies. A total of 212 questionnaires were eventually returned. As a whole, the response rate was 23.56 percent. The above mentioned four organisations received 97, 44, 21, and 50 questionnaires back, respectively. Their respective response rates were 32.23, 24.44, 21.65, and 15.53 percent.

3.3 Respondent Companies

Of these 212 manufacturing companies, 82 were large-sized, 70 medium-sized, and 60 small-sized[1]. The current number of employees working in companies that responded ranged from 75 to 26,809. On average, each firm employed 2,006 employees. Approximately half of the companies exported products to foreign countries. The annual sales of these companies ranged from RMB 10 to 3,500 million. On average, the annual sales were RMB 154 million. Of the companies that responded, 70 firms were losing money, 18 firms were breaking even, and 124 firms were making a profit. Of the 70 money-losing companies, a total of RMB 195 million had been lost. On average, each firm losing money lost RMB 2.80 million. Table 1 lists more information about these respondent companies.

4. Empirical Assessment of the Instrument

In this study, the instrument that was developed consisted of 11 scales (79 items). These scales had to be empirically tested and validated. Many methods were available for empirically assessing the reliability and validity of a measurement scale. This section will detail how the reliability and validity of these scales were evaluated.

[1] Firm sizes were categorized by the Chinese government according to their fixed assets and industrial sectors.

Table 1. Information about the Respondent Companies

Characteristics	Frequency	Percentage (%)
Industrial Sectors		
Machinery	97	45.8
Chemical	44	20.8
Electronics	21	9.9
Building Materials	11	5.2
Textile	11	5.2
Light Industry	10	4.7
Foods Industry	7	3.3
Metallurgical Industry	7	3.3
Medicine Industry	4	1.9
Ownership		
State-owned Company	137	64.6
Collective Company	19	9.0
Township Company	19	9.0
Joint Venture	13	6.1
Others	24	11.3
Establishment Year		
Before 1949	34	16
1950 – 1966	84	39.6
1967 – 1978	48	22.6
1979 – 1990	31	14.6
1991 – 1997	15	7.1

4.1 Reliability

Reliability relates to the extent to which an experiment, test, or any measuring procedure yields the same results on repeated trials (Carmines and Zeller, 1979). It is a statistical measure of how reproducible the data of the survey instrument are (Litwin, 1995). There are four methods which can be used for assessing reliability: (1) the test-retest method, (2) the alternate-form method, (3) the split-halves method, and (4) the internal consistency method (Nunnally, 1967). Of these four methods, internal consistency reliability is the most commonly used psychometric measure in assessing survey instruments and scales. Internal consistency is an indicator of how well the different items measure the same concept. This is important since a group of items purporting to measure one variable should indeed be clearly focused on that variable. Internal consistency is measured by calculating a statistic known as Cronbach's coefficient alpha (Nunnally, 1967; Cronbach, 1951). Coefficient alpha measures internal consistency reliability among a group of items combined to form a single scale. It is a statistic that reflects the homogeneity of the scale. Table 2 lists Cronbach's alpha for different scales. It should be noted that one item was deleted after factor analysis. The table shows that the reliability coefficients ranged from 0.8377 to 0.9245, indicating that some scales were more reliable than the others. Generally, reliability coefficients of 0.70 or more are considered good (Nunnally, 1967). Accordingly, the eleven scales developed for measuring TQM implementation constructs were considered to be reliable.

Table 2. Internal Consistency Analysis for the Eleven Scales

Scales	Number of Items	Deleted Number	Cronbach's alpha
1. Leadership	8	No	0.8922
2. Supplier Quality Management	6	No	0.8377
3. Vision and Plan Statement	8	No	0.9144
4. Evaluation	10	No	0.8895
5. Process Control & Improvement	8	1	0.8611
6. Product Design	8	No	0.8393
7. Quality System Improvement	5	No	0.9245
8. Employee Participation	8	No	0.8829
9. Recognition and Reward	6	No	0.8568
10. Education and Training	6	No	0.8848
11. Customer Focus	6	No	0.8747

4.2 Item Analysis

A method to evaluate the assignment of items to scales was developed by Nunnally (1967). This method considers the correlation of each item with each scale. Specifically, the item-score to scale-score correlations are used to determine whether an item belongs to the scale as assigned, belongs to some other scales, or if it should be deleted. The scale-score is obtained by computing the arithmetic average of the scores of the items that comprise that scale. If an item does not correlate highly with any of the scales, it has to be eliminated. Saraph et al. (1989) used this method to evaluate the assignment of items to scales for developing their instrument. For this study, it was decided that item analysis should be performed in order to understand whether items had been assigned appropriately.

Table 3 lists the correlation matrix for the eleven scales and their measurement items. The correlation matrix shows that the items correlated highly with the scales they intend to measure. All of the values in this table are greater than 0.5. Item values lower than 0.5 do not share enough variance with the rest of the items in that scale. It is therefore assumed that the items are not measuring the same construct, and that it should be deleted from the scale (Kemp, 1999). As an example item-score to scale-score correlation, item 1 in scale 1 had a higher correlation with scale 1 than with the other scales (the correlations between item 1 in scale 1 with scale 1, scale 2, scale 3, ……, and scale 11 were 0.783, 0.581, 0.631, 0.587, 0.555, 0.560, 0.525, 0.559, 0.466, 0.540, and 0.538, respectively. Item correlations with other scales were not given in Table 3 due to text limitation). It was therefore concluded that item 1 in scale 1 had been assigned appropriately to this scale. All other items were similarly examined and the results were satisfactory. It was therefore concluded that all items had been appropriately assigned to scales.

Table 3. Item to Scale Correlation Matrix (Pearson Correlation)

	Item Number									
Scales	1	2	3	4	5	6	7	8	9	10
Scale 1	.784	.810	.709	.702	.851	.624	.751	.816	--	--
Scale 2	.741	.787	.816	.690	.683	.753	--	--	--	--
Scale 3	.844	.861	.553	.861	.859	.863	.652	.823	--	--
Scale 4	.741	.738	.768	.703	.656	.772	.769	.627	.653	.692
Scale 5	.725	.666	.755	.713	.800	.754	.790	.721	--	--
Scale 6	.688	.649	.642	.726	.636	.570	.802	.765	--	--
Scale 7	.782	.913	.914	.939	.844	--	--	--	--	--
Scale 8	.765	.760	.804	.698	.741	.777	.639	.761	--	--
Scale 9	.756	.718	.801	.766	.745	.800	--	--	--	--
Scale 10	.828	.863	.846	.680	.703	.854	--	--	--	--
Scale 11	.813	.737	.838	.849	.649	.813	--	--	--	--

Note: Item number in this table is the same as the item number in the instrument;
The symbol "--" means not available.

4.3 Validity

Validity is defined as the extent to which any measuring instrument measures what it is intended to measure. There are three popular methods to evaluate the validity of scales. These are content validity, criterion-related validity, and construct validity (Carmines and Zeller, 1979).

Content Validity

Content validity depends on the extent to which an empirical measurement reflects a specific domain of content. It cannot be evaluated numerically - it is a subjective measure of how appropriate the items seem to various reviewers who have some knowledge of the subject matter. The evaluation of content validity typically involves an organised review of the survey's contents to ensure that it includes everything it should and does not include anything it should not. Strictly speaking, content validity is not a scientific measure of a survey instrument's accuracy. Nevertheless, it provides a solid foundation on which to build a methodologically rigorous assessment of a survey instrument's validity. In this research, it was argued that the eleven scales for measuring TQM implementation constructs have content validity since the development of the measurement items was mainly based on an extensive review of the literature and detailed evaluations by academicians and practitioners. The references list the literature that was reviewed by the researcher during the period of conducting this study. The detailed process of developing the research instrument was already described more fully in the section on research methodology.

Criterion-related Validity

Criterion-related validity, Nunnally (1978) notes, "is at issue when the purpose is to use an instrument to estimate some important form of behaviour that is external to the measuring instrument itself, the latter being referred to as the criterion". In this study, criterion-related validity was a measure of how well scales representing the various quality management practices are related to measures of product quality performance (the criteria) (Flynn et al., 1994). Product quality performance was measured by asking respondents to rate (on a 5-point scale, 1: worst in the industry; 2: lower than average; 3: average; 4: above average; 5: best in the industry) seven indexes compared with the other companies within the same industry in China (see the Appendix). These indexes included, for example, performance, conformity rates, reliability, durability, defect rates of their primary products, internal failure costs and warranty claims costs as a percentage of their annual sales. In this study, correlation analysis was employed for testing criterion validity. Accordingly, bivariate correlation (Pearson) was conducted to study the interrelationships between the independent and dependent variable sets: the TQM implementation (predictor set) and the product quality performance measures (the criterion set). Their bivariate correlation coefficients are listed in Table 4. Fortunately, the correlation within the eleven scales (predictor set), within the seven measures (criterion set), between the predictor set and criterion set was significant at the 0.01 level. It can therefore be concluded that this set of scales has good criterion-related validity.

Construct Validity

Construct validity measures the extent to which the items in a scale all measure the same construct (Flynn et al., 1994). The construct validity can be evaluated by the use of factor analysis. Factor analysis addresses the problem of analysing the interrelationships between a large number of variables and then explaining these variables in terms of their common underlying dimensions (factors). The general purpose of factor analysis is to find a way of condensing or summarising the information into a smaller set of new composite dimensions (factors) with a minimum loss of information (Hair et. al., 1992). There are two forms of factor analysis, namely, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

EFA is designed for a situation where links between the observed and latent variables are unknown or uncertain. The analysis thus proceeds in an exploratory mode to determine how and to what extent the observed variables are linked to their underlying factors (Byrne, 1998). Factor loadings are used to present these relations. EFA helps to identify whether selected items cluster on one or more than one factor. The unidimensionality of factors is thus assessed. Usually, three or more items are selected for a latent variable or construct. However, the aim of CFA is to test or confirm a prespecified relationship between indicators and latent variables. In respect of this study’s characteristics, EFA would have to be employed for construct validation. Accordingly, principal component analysis was performed and each scale was factor analysed separately. The detailed results are listed in Table 5.

Table 4. Bivariate Correlation Matrices

(a) Within Predictor Set (TQM Implementation Scales)

Scales	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
Scale 1	3.90	.69	1.000										
Scale 2	3.68	.67	.749	1.000									
Scale 3	3.83	.74	.823	.802	1.000								
Scale 4	3.68	.65	.757	.788	.853	1.000							
Scale 5	3.57	.67	.717	.749	.789	.822	1.000						
Scale 6	3.64	.61	.716	.644	.765	.764	.775	1.000					
Scale 7	3.73	.99	.655	.703	.781	.719	.745	.660	1.000				
Scale 8	3.68	.65	.749	.722	.809	.813	.806	.753	.717	1.000			
Scale 9	3.70	.68	.650	.704	.732	.758	.739	.665	.611	.789	1.000		
Scale 10	3.68	.70	.752	.731	.810	.780	.788	.696	.739	.824	.764	1.000	
Scale 11	4.00	.64	.720	.710	.789	.755	.744	.694	.710	.803	.738	.816	1.000

Note: Pearson Correlation is significant at the 0.01 level; S.D. means standard deviation; Number is 212.

(b) Within Criterion Set (Product Quality Measures)

Product Quality Measures	Mean	S.D.	1	2	3	4	5	6	7
1. The performance of your primary products	3.97	0.89	1.000						
2. The conformity rates of your primary products	3.99	0.88	.838	1.000					
3. The reliability of your primary products	4.02	0.80	.796	.850	1.000				
4. The durability of your primary products	4.01	0.80	.760	.793	.856	1.000			
5. The defect rates of your primary products	3.61	0.96	.474	.575	.510	.513	1.000		
6. The internal failure costs as a percentage of annual sales	3.57	0.92	.548	.603	.595	.520	.791	1.000	
7. The warranty claims costs as a percentage of annual sales	3.61	0.94	.559	.613	.599	.576	.747	.869	1.000

Note: Pearson correlation is significant at the 0.01 level; S.D. means standard deviation; Total number is 212.

(c) Between Predictor Set and Criterion Set

TQM Implementation Scales	Product Quality Measures 1	2	3	4	5	6	7	Average Seven Measures
1. Leadership	.631	.611	.587	.547	.390	.409	.418	.603
2. Supplier Quality Management	.524	.561	.574	.506	.346	.419	.378	.555
3. Vision and Plan Statement	.617	.645	.634	.563	.364	.460	.429	.622
4. Evaluation	.608	.628	.612	.565	.371	.432	.393	.605
5. Process Control and Improvement	.623	.646	.630	.553	.422	.523	.467	.650
6. Product Design	.536	.576	.535	.500	.371	.441	.404	.566
7. Quality System Improvement	.544	.569	.544	.508	.301	.341	.316	.522
8. Employee Participation	.547	.605	.568	.531	.351	.434	.388	.574
9. Recognition and Reward	.468	.530	.538	.463	.442	.475	.401	.560
10. Education and Training	.587	.598	.575	.519	.390	.456	.409	.594
11. Customer Focus	.572	.601	.581	.509	.384	.465	.428	.595

Note: Pearson correlation is significant at the 0.01 level; Total number is 212.

Table 5. Results of Exploratory Factor Analysis for the Eleven Scales

Scales	Number of Factors		Eigen-values	Factor Loadings Item1	Item2	Item3	Item4	Item5	Item6	Item7	Item8	Item9	Item10	% of Variance
Scale 1	1		4.620	0.784	0.802	0.725	0.677	0.839	0.644	0.770	0.816			57.750
Scale 2	1		3.394	0.748	0.808	0.817	0.696	0.665	0.737					55.820
Scale 3	1		5.095	0.848	0.861	0.531	0.875	0.873	0.873	0.630	0.815			63.692
Scale 4	2	(factor 1)	5.106	0.737	0.679	0.731	0.751	0.701	0.671	0.797	0.785	0.647	0.627	51.062
		(factor 2)	1.009	0.223	0.170	0.269	0.020	-0.094	-0.379	-0.294	-0.589	0.273	0.444	10.095
Scale 5	2	(factor 1)	4.405	0.727	0.677	0.765	0.725	0.793	0.751	0.777	0.714			55.060
		(factor 2)	1.019	0.313	0.492	0.395	0.138	-0.080	-0.408	-0.333	-0.469			12.734
Scale 6	1		3.797	0.709	0.665	0.661	0.712	0.637	0.572	0.789	0.745			47.469
Scale 7	1		3.878	0.795	0.904	0.902	0.940	0.855						77.561
Scale 8	1		4.443	0.754	0.740	0.806	0.705	0.754	0.781	0.637	0.773			55.539
Scale 9	1		3.514	0.761	0.699	0.759	0.776	0.747	0.810					58.572
Scale 10	1		3.834	0.833	0.858	0.844	0.674	0.718	0.848					63.895
Scale 11	1		3.710	0.819	0.748	0.825	0.842	0.657	0.813					61.883

Note: An eigenvalue greater than 1 was used as criterion for factor extraction

From this table, it was very clear that all of the items had factor loadings that were greater than 0.50 on factor 1. Factor loadings greater than 0.30 are considered significant; loadings of 0.40 are considered more important; if the loadings are 0.50 or greater, they are considered very significant (Hair et al., 1992). In this study, a factor loading of 0.50 was used as the cut-off point. When the items in a scale loaded on more than one factor, the rotated (varimax, quartimax if necessary) solution was examined. The factor analysis showed that the items in nine of the eleven scales formed a single factor, except for scale 4 (Evaluation) and scale 5 (Process Control and Improvement). In the cases of the scales for Evaluation and Process Control and Improvement, two factors emerged according to the criterion of eigenvalues greater than 1. Since the latent root criterion (eigenvalue) is the most commonly used technique for factor extraction, it was therefore selected as criterion for factor extraction. In component analysis, only the factors having eigenvalues greater than 1 are considered significant; all factors with eigenvalues less than 1 are considered insignificant and disregarded. Although percentage of variance and scree test can also be used as criteria for factor extraction, the two criteria are however too subjective. For example, in the social sciences, where information is often less precise, it is not uncommon for the analyst to consider a solution that accounts for 60 percent of the total variance (and in some instances even less) as a satisfactory solution (Hair et al., 1992).

Table 6 lists the unrotated factor and rotated factor matrix for scale 4 (Evaluation). From this table, it was very clear that item 1, 2, 3, 4, 9, and 10 constituted a factor which can be interpreted as the factor of Audit. The other four items in scale 4 were in the other factor, which formed the factor of Use of Quality-Related Information. Evaluation has therefore two dimensions, namely, Audit and Quality-Related Information.

Table 6. Factor Matrix for Scale 4 (Evaluation)

	Unrotated Factor		Rotated (Varimax) Factor	
Scale 4	1	2	1	2
Item 1	.737	.223	**.701**	.319
Item 2	.731	.170	**.661**	.354
Item 3	.751	.269	**.742**	.294
Item 4	.701	.020	**.540**	.447
Item 5	.671	-.094	.442	**.513**
Item 6	.797	-.379	.348	**.811**
Item 7	.785	-.294	.395	**.739**
Item 8	.647	-.589	.098	**.870**
Item 9	.627	.273	**.652**	.209
Item 10	.679	.444	**.803**	.114

Table 7. Factor Matrix for Scale 5 (Process Control and Improvement)

	Unrotated Factor		Rotated Factor (Varimax)		Rotated Factor (Quartimax)	
Scale 5	1	2	1	2	1	2
Item 1	.727	.313	.295	**.734**	**.753**	.245
Item 2	.677	.492	.134	**.826**	**.833**	.077
Item 3	.765	.395	.264	**.820**	**.836**	.208
Item 4	.725	.138	.417	**.609**	**.636**	.375
Item 5	.793	-.080	**.619**	**.503**	**.544**	**.583**
Item 6	.751	-.408	**.820**	.240	.295	**.802**
Item 7	.777	-.333	**.786**	.311	.364	**.763**
Item 8	.714	-.469	**.837**	.171	.228	**.823**

Table 7 lists the unrotated factor and rotated (varimax and quartimax) factor matrix for scale 5 (Process Control and Improvement). After orthogonal and oblique factor rotation was done, it was not easy to decide whether item 5 belonged to factor 1 or factor 2. Item 5 loaded very significantly on both factor 1 and factor 2. After the content of item 5 was examined, it was decided that item 5 (our processes are designed to be “fool proof” in order to minimise the chance of employee error) should be deleted from this scale. Thus, item 1, 2, 3, and 4 formed a factor that can be interpreted as Process Control. Similarly, item 6, 7, and 8 constituted a factor which can be interpreted as Use of Quality Management Methods. Process Control and Improvement therefore has two dimensions, namely, Process Control and Use of Quality Management Methods. It was finally concluded that the eleven TQM implementation scales consisting of 78 items had good construct validity.

5. Discussion and Conclusions

Compared to the other quality management instruments developed by Saraph et al. (1989), Flynn et al. (1994), and Ashire et al. (1996), the instrument presented in this paper has several unique characteristics.

Firstly, this instrument covers a broader scope of TQM in comparison with their instruments. Ashire et al. (1996) strongly recommended that a combination of the three instruments should be undertaken for future research on quality management. Following their suggestions, all of the constructs in the three instruments were carefully examined. The author tried to integrate their constructs into this instrument as much as possible. Table 8 lists the comparison of these instruments. The two constructs, namely, Product Quality and Supplier Performance in the Ashire et al. instrument, were not included in this instrument since they represent TQM outcomes. Role of Quality Department in the Saraph et al. instrument was excluded in this instrument since every department in any organisation is involved in quality management. Benchmarking and Internal Quality Information Usage in the Ashire et al. instrument were integrated to form the construct of Evaluation in this instrument. Process Control and Cleanliness and Organisation in the Flynn et al. instrument were combined to formulate the construct of Process Control and Improvement in this instrument. This instrument includes two more constructs, namely, Quality System Improvement and Vision and Plan Statement, which are not found in their instruments. In addition, this instrument has 78 measurement items in total, which is more than their items. This instrument therefore covers a broader scope of TQM.

Table 8. Construct Comparison

This Instrument	Saraph et al. Instrument	Flynn et al. Instrument	Ashire et al. Instrument
1 Leadership	1 Role of divisional top management and quality policy	1 Quality leadership	1 Top management commitment
2 Supplier quality management	2 Role of quality department	2 Quality improvement rewards	2 Customer focus
3 Vision and plan statement	3 Training	3 Process control	3 Supplier quality management
4 Evaluation	4 Product/service design	4 Feedback	4 Design quality management
5 Process control and improvement	5 Supplier quality management	5 Cleanliness and organisation	5 Benchmarking
6 Product design	6 Process management/operating procedures	6 New product quality	6 SPC usage
7 Quality system improvement	7 Quality data and reporting	7 Interfunctional design process	7 Internal quality information usage
8 Employee participation	8 Employee relations	8 Selection for teamwork potential	8 Employee empowerment
9 Recognition and reward		9 Teamwork	9 Employee involvement
10 Education and training		10 Supplier relationship	10 Employee training
11 Customer focus		11 Customer involvement	11 Product quality
			12 Supplier performance

Secondly, specific characteristics of Chinese manufacturing companies were taken into account in developing this instrument. Since the aim of this research was to develop an instrument for measuring TQM implementation for Chinese manufacturing companies, the instrument had to be made suitable for use in China. Thus, specific characteristics of Chinese manufacturing companies had to be taken into account when developing this instrument. For example, most Chinese companies are weak in terms of their visions and plans. Vision and Plan Statement is therefore one construct in this instrument. Most Chinese companies are trying to implement ISO 9000 in order to improve their quality systems. This instrument thus includes the construct of Quality System Improvement. Some Chinese top managers prefer to pursue short-term business success because of the nature of the country's institutional system. Item 8 (top management pursues long-term business success) in scale 1 (Leadership) is therefore a very important item for measuring leadership of Chinese manufacturing companies. This item cannot be found from the existing instruments. Most Chinese companies implement reward and penalty measures for strengthening their management. An item "employees' rewards and penalties are clear" was therefore developed for scale 9 (Recognition and Reward). For details, please refer to the Appendix, and note that it is beyond the scope of this paper to address the characteristics of Chinese manufacturing companies.

Thirdly, this instrument has the highest external validity for manufacturing industries in general and for Chinese manufacturing companies in particular. For testing and validating this instrument, the author used data from 212 Chinese manufacturing companies in nine industrial sectors. This instrument has the highest level of external validity for manufacturing industries in general and for Chinese manufacturing companies in particular. While its internal consistency falls behind the Flynn et al. instrument and the Ashire et al. instrument, it is however better than the Saraph et al. instrument. Saraph et al. (1989) used data from 162 general and quality managers in 89 divisions of 20 manufacturing and service companies. A main strength of Saraph et al. instrument is its highest level of external validity for manufacturing and service industries (Ashire et al., 1996). Flynn et al. (1994) employed data from 716 respondents at 42 plants in the transportation components, electronics and machinery industries. The focus of their instrument is more on manufacturing industries within limited sectors. Their instrument has the second highest internal validity. Its external validity is however better than the Ashire et al.

instrument. Ashire et al. (1996) utilised data from 371 manufacturing company in a single industry – motor vehicle parts and accessories for validating their instrument. Their instrument therefore has the highest internal consistency, but its external validity is the lowest. Ahire et al. (1996) summarised the differences and similarities of the three instruments in their paper.

In this study, data used for testing and validating this instrument only came from 212 manufacturing companies with annual sales more than RMB 10 million in the Liaoning region. Strictly speaking, the generalisation is limited, although this study was the first one to aim at developing an instrument for measuring TQM implementation for Chinese manufacturing companies. In order to improve external validity of the instrument, additional studies would be needed with increased sample sizes, geographical diversity, company type diversity, and so on.

Although this instrument was empirically tested and validated using data from Chinese manufacturing companies, researchers and practitioners from other countries will be able to use it. The reason is that this instrument was developed on the basis of an extensive literature review. However, it should be noted that this instrument is more valid for Chinese manufacturing companies than for companies in other countries.

In summary, the empirically validated TQM implementation instrument consisting of 11 scales (78 items) is reliable and valid. This validated instrument can be used directly in other studies for different populations. Industrial managers will be able to use this instrument to evaluate their TQM implementation programs and identify problem areas that should be improved. Researchers will be able to use this instrument to develop quality management theory.

Appendix

TQM Implementation Instrument

5-Likert scale (1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree) was used to ask the respondents to state how much they agree with these statements.

Scale 1: Leadership

(1) Top management actively participates in quality management and improvement process.
(2) Top management learns quality-related concepts and skills.
(3) Top management strongly encourages employee involvement in quality management and improvement activities.
(4) Top management empowers employees to solve quality problems.
(5) Top management arranges adequate resources for employee education and training.
(6) Top management discusses many quality-related issues in top management meetings.
(7) Top management focuses on product quality rather than yields.
(8) Top management pursues long-term business success

Scale 2: Supplier Quality Management

(1) Our company has established long-term co-operative relations with suppliers.
(2) Our company regards product quality as the most important factor for selecting suppliers.
(3) Our company always participates in supplier activities related to quality.
(4) Our company always gives feedback on the performance of suppliers' products.
(5) Our company has detailed information about supplier performance.
(6) Our company regularly conducts supplier quality audit.

Scale 3: Vision and Plan Statement

(1) Our company has a clear long-term vision statement.
(2) The vision effectively encourages employees' commitment to quality improvement.

(3) Our company has a clear short-term business plan.
(4) Our company has a clear quality policy.
(5) Our company has a detailed quality goal.
(6) Our company has an effective quality improvement plan.
(7) Various policies and plans are well communicated to the employees.
(8) Employees from different levels are involved in making policies and plans.

Scale 4: Evaluation

(1) Our company regularly audits various policies and strategies.
(2) Our company regularly conducts quality audits.
(3) Benchmarking is used extensively in our company.
(4) Our company uses quality-related costs extensively.
(5) Our company has detailed quality-related data such as defect rates and scraps.*
(6) Quality-related data are used to evaluate the management of our company.*
(7) Quality-related data are used to evaluate the performance of all departments.*
(8) Quality-related data are used to evaluate the performance of employees.*
(9) Quality-related information is displayed at the shop floor.
(10) The aim of evaluation is for improvement, not for criticism.

Scale 5: Process Control and Improvement

(1) Our company is kept neat and clean at all times.
(2) Process capability can meet production requirements.
(3) Production equipment is maintained well according to maintenance plan.
(4) Our company implements various inspections effectively (e.g., incoming, process, final products).
(5)# Our processes are designed to be "fool proof" in order to minimise the chance of employee error.
(6) Our company uses the Seven QC tools extensively for process control and improvement.*
(7) Our company uses SPC extensively for process control and improvement.*
(8) Our company uses PDCA cycle extensively for process control and improvement.*

Scale 6: Product Design

(1) The design engineers are required to have some shop floor experiences.

(2) The design engineers are required to have some marketing experiences.
(3) The customer requirements are thoroughly considered in new product design.
(4) Various departments participate in new product development.
(5) New product designs are thoroughly reviewed before production.
(6) Cost is emphasised in the product design process.
(7) Experimental design is used extensively in product design.
(8) Quality function deployment (QFD) is used extensively in product design.

Scale 7: Quality System Improvement

(1) The quality system in our company is continuously improved.
(2) Our company uses ISO 9000 as a guideline for establishing our quality system.
(3) Our company has a clear quality manual.
(4) Our company has clear procedure documents.
(5) Our company has clear working instructions.

Scale 8: Employee Participation

(1) Our company has cross-functional teams.
(2) Our company has several QC circles (within one function).
(3) Employees are actively involved in quality-related activities.
(4) Our company implements suggestion activities extensively.
(5) Most employees' suggestions are implemented after an evaluation.
(6) Employees are very committed to the success of our company.
(7) Employees are encouraged to fix problems they find.
(8) Reporting work problems is encouraged in our company

Scale 9: Recognition and Reward

(1) Our company improves working conditions in order to recognise employee quality improvement efforts.
(2) Our company has a salary promotion scheme for encouraging employee participating in quality improvement.
(3) Position promotions are based on work quality in our company.
(4) Excellent suggestions are financially rewarded.
(5) Employees' rewards and penalties are clear.
(6) Recognition and reward activities effectively stimulate employee commitment to quality improvement

Scale 10: Education and Training

(1) Employees are encouraged to accept education and training in our company.

(2) Resources are available for employee education and training in our company.

(3) Most employees in our company are trained on how to use quality management methods (tools).

(4) Quality awareness education is given to employees.

(5) Specific work-skills training is given to all employees.

(6) Employees are regarded as valuable, long-term resources worthy of receiving education and training throughout their career.

Scale 11: Customer Focus

(1) Our company collects extensive complaint information from customers.

(2) Quality-related customer complaints are treated with top priority.

(3) Our company conducts a customer satisfaction survey every year.

(4) Our company always conducts market research in order to collect suggestions for improving our products.

(5) Our company provides warranty on our sold products to customers.

(6) Our company has been customer focused for a long time.

Note: *# means that this item was deleted after factor analysis;*
** means that these items in that scale formed a factor and the other items in that scale formed another factor.*

Measurement for Product Quality

Compared with the other companies within the same industry in China, please state the situation of your primary products (1: Worst in the industry; 2: Lower than average; 3: Average; 4: Above average; 5: Best in the industry).

(1) The performance of your primary products

(2) The conformity rates of your primary products

(3) The reliability of your primary products

(4) The durability of your primary products

(5) The defect rates of your primary products

(6) The internal failure costs as a percentage of annual sales

(7) The warranty claims costs as a percentage of annual sales

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